

ESTABLISHMENT OF *HIPPODAMIA VARIEGATA* AND NEW RECORDS OF *PROPYLEA* *QUATUORDECIMPUNCTATA* (COLEOPTERA: COCCINELLIDAE) IN THE EASTERN UNITED STATES¹

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ABSTRACT: *Hippodamia variegata* is a Palearctic coccinellid known previously in North America from a few areas of eastern Canada. It has been released in eastern and western states for biological control of aphids, but its establishment in the United States has not been documented. On the basis of late-season surveys in the northeast in 1992, *H. variegata* is reported from 38 counties in eight states from northern New England to eastern Pennsylvania and northern New Jersey. All localities surveyed are mapped. Its abundance relative to other coccinellines collected on weeds in disturbed habitats and its plant associations are indicated; the origin of U.S. populations is discussed. Records for *Propylea quatuordecimpunctata*, another Old World coccinellid, are given for Massachusetts, New Hampshire, New York, and Vermont.

Hippodamia (Adonia) variegata (Goeze) is an Old World coccinellid first recorded from North America by Gordon (1987). He reported its establishment in the vicinity of Montreal, Quebec, noting that Nearctic populations may be adventive rather than the result of intentional releases. This aphid predator was released in the United States (Arizona, California, Florida, and Georgia) beginning in 1957-1958, but no record of Canadian releases is available (Gordon 1985, 1987).

Hippodamia variegata (South African strain) was evaluated in the laboratory (and eventually released) as a potential biological control agent of the greenbug, *Schizaphis graminum* (Rondani), that could increase the diversity of coccinellid predators in Texas sorghum fields (Michels and Bateman 1986). Invasion of the western United States by the Russian wheat aphid, *Diuraphis noxia* (Mordvilko), in 1986 (Stoetzel 1987), led to foreign exploration for natural enemies of this introduced pest and the introduction of various strains of *H. variegata* from Eurasia. In 1987, it was released in several eastern and western states by the USDA's Animal and Plant Health Inspection Service (APHIS) (Obrycki and Orr 1990, Flanders *et al.* 1991). Several biological studies on this introduced aphidophagous coccinellid have been conducted in North America, including its developmental rates at several constant temperatures (Michels and Bateman 1986) and an evaluation of several

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aphid species as suitable prey (Obrycki and Orr 1990).

Despite numerous releases in western and eastern states since 1987 (including Colorado, Kansas, Maryland, Massachusetts, New Mexico, Pennsylvania (Flanders *et al.* 1991), and New Jersey (R. Chianese, personal communication), *H. variegata* has been recorded in North America only from Quebec and Ontario (Gordon and Vandenberg 1991, McNamara 1991). Since 1990, participants in the USDA's Cooperative Agricultural Pest Survey (CAPS) have been asked to look for *H. variegata* in the northeast.

The purpose of this paper is to document the establishment of *H. variegata* in eight northeastern states, map the known U. S. range, and provide information on its abundance relative to other coccinellids occurring in the same habitats. In addition, new records are given for *Propylea quatuordecimpunctata* (L.), another coccinellid that CAPS participants have been asked to search for in northeastern states.

METHODS

After I discovered *H. variegata* in New York and Vermont in late August 1992, surveys were begun to help determine the extent of its northeastern range. The habitats surveyed (11-13, 18-20, and 27 September, and 6 October) were those that seemed likely to support a diverse coccinellid fauna, particularly disturbed, weedy sites such as railroad yards and urban vacant lots. Mowed roadside vegetation generally yielded few coccinellids, and cropland was not surveyed because of the time that would have been needed to obtain permission for sampling.

Herbaceous vegetation was swept with a standard insect net, and all adult Coccinellini and numbers of each species (except in late August and early October) were recorded. At some sites, particular plant species were examined to determine host associations of *H. variegata*. Totals of all species at a site include adults collected by both techniques. Even though the duration of sampling (usually 10-15 minutes), number of sweeps, and vegetation varied among the sites, the numbers of coccinellines recorded at a given locality allow comparisons of relative density between *H. variegata* and other coccinellids present during September.

Specimens thought to represent *H. variegata* (and those of several other species that could not be identified accurately in the field) were collected for subsequent determination. Voucher material of *H. variegata* and *Propylea quatuordecimpunctata* has been deposited in collections at Cornell University, Ithaca, NY (CUIC); National Museum of Natural History, Washington, DC (USNM); and Pennsylvania Department of Agriculture, Harrisburg (PADA).

RESULTS

Eleven coccinelline species in six genera were encountered during surveys for *Hippodamia variegata* (Table 1). Nearly 250 specimens of *H. variegata* were obtained at 48 localities in eight states: Connecticut (5 counties), Massachusetts (6), New Hampshire (2), New Jersey (1), New York (16), Pennsylvania (3), Rhode island (1), and Vermont (4). Positive and negative sites for *H. variegata*, as well as recent release sites in Massachusetts, New Jersey, and Pennsylvania, are shown in Fig. 1.

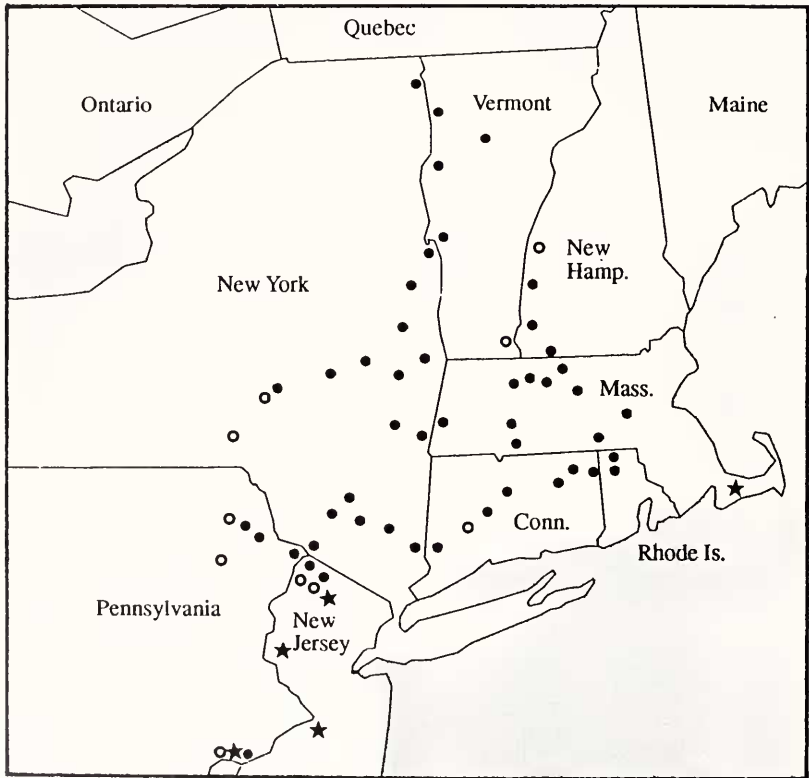


Figure 1. Known U.S. distribution of *Hippodamia variegata*. Dots = detection sites; circles = sites where the coccinellid was not found; stars = recent release sites in Massachusetts, New Jersey, and Pennsylvania (not shown are 1957-1958/1987 release sites in Delaware, Maine, and Maryland).

The following new records document the establishment of *H. variegata* in the eastern United States; all collections were made by the author from 28 August to 6 October 1992.

CONNECTICUT: Fairfield Co., Danbury; Hartford Co., New Britain; New Haven Co., Waterbury; Tolland Co., Mansfield; Windham Co., Abington and Dayville. MASSACHUSETTS: Berkshire Co., Rt. 41 S. of Housatonic; Franklin Co., Erving and Greenfield; Hampden Co., Springfield; Hampshire Co., Northampton; Middlesex Co., Marlborough; Worcester Co., Athol, Gardner, Millbury, and Winchendon. NEW HAMPSHIRE: Cheshire Co., North Walpole and Troy; Sullivan Co., Claremont. NEW JERSEY: Sussex Co., McAfee and Rt. 23 E. of Montague. NEW YORK: Albany Co., Rt. 90E, Service Plaza, Town of Rotterdam nr. Albany; Clinton Co., junc. rts. 87 & 456 E. of Beckmantown; Columbia Co., Hillsdale; Dutchess Co., Fishkill; Greene Co., Leeds; Orange Co., Newburgh and Port Jervis; Otsego Co., Cooperstown Junction; Putnam Co., Brewster; Rensselaer Co., Brunswick; Saratoga Co., Ballston Spa; Schenectady Co., Duanesburg; Schoharie Co., Cobleskill; Sullivan Co., Wurtsboro; Ulster Co., Kerhonkson; Warren Co., Glens Falls; Washington Co., Whitehall. PENNSYLVANIA: Philadelphia Co., Philadelphia; Pike Co., Matamoras; Wayne Co., Hawley and Waymart. RHODE ISLAND: Providence Co., Chepachet and Nasonville. VERMONT: Addison Co., Vergennes; Chittenden Co., Colchester; Rutland Co., Fair Haven; Washington Co., Montpelier.

In northern New England and northeastern New York, *H. variegata* was found at 20 of 29 sites sampled during 11-13 September. It was either the only coccinellid species or the most numerous one at 13 of those sites. During 18-20 September, it was present at 22 of 24 sites in southern New England, southeastern New York, and eastern Pennsylvania and was most abundant at 11 sites. It was taken at 4 of 9 sites in northeastern Pennsylvania and northern New Jersey on 27 September and was most numerous at 2 sites. It was found at one location in Philadelphia during limited surveys in southeastern Pennsylvania on 6 October.

Hippodamia variegata was frequently taken by sweeping legumes such as red clover (*Trifolium pratense* L.) and sweet clover (*Melilotus* spp.) that were infested with pea aphids, *Acyrtosiphon pisum* (Harris), or by beating inflorescences of horseweed (*Conyza canadensis* (L.) Cronquist). It was also observed on volunteer alfalfa (*Medicago sativa* L.) and on composites such as aster (*Aster* spp.), chicory (*Cichorium intybus* L.), goldenrod (*Solidago* spp.), mugwort (*Artemisia vulgaris* L.), ragweed (*Ambrosia artemisiifolia* L.), spotted knapweed (*Centaurea maculosa* Lam.), and tansy (*Tanacetum vulgare* L.). A mating pair was found under a mat of knotweed (*Polygonum aviculare* L.).

An adult *H. variegata* collected 20 September at Marlborough, Massachusetts, was not killed right away. A few days later a parasitoid cocoon was observed beneath its body, and the braconid *Dinocampus coccinellae* (Schrank) emerged on 3 October. This Holarctic species is a

known parasitoid of *H. variegata* (and other coccinellids) in Europe. The Massachusetts record from *H. variegata* is noteworthy because this coccinellid had proved unsuitable as a host (100% mortality) in laboratory studies using North American *D. coccinellae* (Obrycki 1989). Successful parasitism of Canadian populations of *H. variegata* has since been reported (Orr *et al.* 1992).

Propylea quatuordecimpunctata was collected in 16 counties in four states: Massachusetts (1 county), New Hampshire (1), New York (9), and Vermont (5). It occurred at 11 of 29 sites during 11-13 September (and was most abundant at 1 site) and 3 of 24 sites the following week. It was not found during surveys of northeastern Pennsylvania and northern New Jersey on 27 September or in the limited southeastern Pennsylvania surveys on 6 October. The largest number of specimens (>20; not shown in Table 1) was observed in late August at the Clinton Co., New York, site listed below. The following records of *P. quatuordecimpunctata* were obtained from 28 August to 27 September 1992.

MASSACHUSETTS: Franklin Co., Greenfield. NEW HAMPSHIRE: Grafton Co., West Lebanon. NEW YORK: Albany Co., Rt. 90E, Service Plaza, Town of Rotterdam nr. Albany; Clinton Co., junc. rts. 87 & 456 E. of Beekmantown; Dutchess Co., Fishkill; Orange Co., Newburgh; Putnam Co., Brewster; Rensselaer Co., Brunswick; Saratoga Co., Ballston Spa; Warren Co., Glens Falls; Washington Co., Whitehall. VERMONT: Addison Co., Vergennes; Chittenden Co., Colchester; Rutland Co., Fair Haven; Washington Co., Montpelier; Windham Co., Brattleboro.

DISCUSSION

Hippodamia variegata should be considered a common and widespread coccinellid in the northeastern states; the localities reported herein can be regarded as the first records of establishment in the United States. It was generally present in the areas surveyed except in more western portions of eastern New York and in parts of northern New Jersey and eastern Pennsylvania.

The current U.S. range of *H. variegata* could reflect expansion of Canadian populations discovered in 1984 (Gordon 1987). As noted earlier, it cannot be determined if this coccinellid's occurrence in Quebec is the result of a fortuitous importation with commerce or deliberate introduction associated with biological control work. Its extensive northeastern distribution suggests *H. variegata* was present in the United States when Gordon (1987) gave Quebec as the first North American record.

Rather than having spread rapidly from the Montreal area, this coccinellid may be present in the eastern states as a result of earlier U.S. releases (probably those since 1987 rather than ones during 1957-1958)

that led to its establishment, which is only now being documented. Schaefer *et al.* (1987) offered a similar hypothesis as one explanation of the North American origin of *Coccinella septempunctata*: that establishment from earlier biocontrol releases went undetected for several years. Northeastern and southeastern Pennsylvania populations of *H. variegata* may be discontinuous, and its occurrence in Philadelphia may be the result of 1987 releases there, even though recovery attempts have been unsuccessful (Flanders *et al.* 1991). Similarly, the New Jersey populations may be the result of establishment from 1991 releases (see Fig. 1).

Evidence for evaluating the status of *H. variegata* in the New World—adventive or indigenous—is meager, emphasizing a general need for more field work and documentation of insect distributions. It also points to the desirability of recording all sites where nonindigenous organisms are released for biological control purposes and of conducting thorough recovery surveys to determine whether establishment has taken place. Areas well removed from release sites should be surveyed to allow for dispersal by highly mobile species.

That *H. variegata* was the most abundant coccinellid occurring at several sites was surprising. The comments to be made on other species collected during the survey are speculative because numerous factors affect the composition and abundance of coccinellid communities (Hagen 1962, Hodek 1973, Honek 1985), and widely distributed species can vary intraspecifically in various diapause characteristics (Hodek 1973; Obrycki and Tauber 1981, 1982; Tauber *et al.* 1986).

The small numbers of *Adalia bipunctata* taken on herbaceous plants during the survey were expected because it prefers arboreal habitats (Hodek 1973, Honek 1985). The generalist *P. quatuordecimpunctata*, which was not abundant in the survey, tends to occur at relatively low densities (Honek 1985). This is a distinctive, easily recognized coccinellid, and, in contrast to *H. variegata*, its establishment and spread in the United States have been documented (Dysart 1988, Wheeler 1990). *Coccinella septempunctata*, a Palearctic species that has spread rapidly to become the most common member of the genus east of the Rocky Mountains (Gordon and Vandenberg 1991), was found in relatively low numbers during the September survey. The convergent lady beetle, *H. convergens*, superficially resembles *H. variegata* in dorsal color pattern, and the abundance of this native species was thought to be hindering detection of *H. variegata* in the East. Only one adult *H. convergens*, however, was collected during the survey.

The small numbers of *C. septempunctata* and *H. convergens* seen in September do not necessarily indicate low densities for the entire season.

In a New Jersey study, the number of both species that were swept from herbaceous weeds declined rapidly through August from much higher June-July levels and were low in September. *Coccinella septempunctata* shows a prolonged aestival-autumnal-hibernal diapause (Obrycki and Tauber 1981), and in New Jersey it began to aggregate as early as mid-July (Angalet *et al.* 1979). *Hippodamia convergens* does not enter aestival diapause in the Ithaca, New York, area (Obrycki and Tauber 1981), but it probably also would have been more abundant in the present study if sites had been sampled earlier in the season.

In contrast, the failure to collect *Coccinella novemnotata* during the survey possibly reflects its current scarcity. Biological control releases of the Palearctic *C. septempunctata* may be contributing to the declining numbers observed recently in populations of the native *C. novemnotata*.³ In Virginia, the dominance of *C. septempunctata* is thought responsible for the disappearance of both *C. novemnotata* and *H. convergens* from alfalfa fields.⁴

Detection of *H. variegata* at additional northeastern localities is favored by the absence or low density of *H. convergens* in late season. Where these species co-occur in the East, *H. variegata* adults generally can be recognized in the field by their smaller size compared to the convergent lady beetle. Field identifications must be substantiated by microscopically observing a fine raised margin or bead at the pronotal base (absent in *H. convergens* and similar-appearing eastern species of the genus) and the white anterior coxae (black in *H. convergens*). Gordon (1987) and Gordon and Vandenberg (1991) provide additional characters for recognizing this quite variable coccinellid.

Further survey work undoubtedly will show that *H. variegata* is even more widely distributed in eastern North America. Its continued spread in the East, establishment in agroecosystems, association with various aphid prey and impact on their densities, and possible effects on populations of native coccinellids such as *H. convergens* require further study.

³ "Biological Control, Predators, and Strategy," a paper presented by R. D. Gordon, 24 September 1991, at annual meeting of the Eastern Branch, Entomological Society of America, Richmond, Virginia.

⁴ "Apparent Displacement of the Convergent Lady Beetle by the Sevenspotted Lady Beetle," a paper presented by R. L. Pienkowski, 24 September 1991, at the annual meeting of the Eastern Branch, Entomological Society of America, Richmond, Virginia.

Table 1. Adult Coccinellini collected during surveys for *Hippodamia variegata* in north-eastern United States, September 1992.^a

Species	No. of Specimens	No. of Sites	Maximum No. Collected
<i>Adalia bipunctata</i> L.	3	2	2
<i>Coccinella septempunctata</i> L.	66	23	12
<i>C. transversoguttata richardsoni</i> Brown	1	1	1
<i>C. trifasciata perplexa</i> Mulsant	8	5	3
<i>Coleomegilla maculata lengi</i> Timberlake	67	29	12
<i>Cycloneda munda</i> (Say)	92	24	23
<i>Hippodamia convergens</i> Guerin	1	1	1
<i>H. glacialis glacialis</i> (F.)	7	4	3
<i>H. parenthesis</i> (Say)	102	30	22
<i>H. variegata</i> (Goeze)	210	45	27
<i>Propylea quatuordecimpunctata</i> L.	24	14	5

^a Numbers of *H. variegata*, *Propylea quatuordecimpunctata*, and other species collected during 28-29 Aug. and 6 Oct. 1992 are not included.

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